

METHODOLOGY

The International Co-Control Benefits Analysis Program (ICAP) has developed a common analytical framework and methodology that the participating countries are applying in their analysis of the public health benefits of integrated strategies for greenhouse gas mitigation and environmental improvement. The methodology is based, in part, on the body of work carried out by the US EPA to analyze ancillary benefits and costs of environmental legislation, including the Clean Air Act. For application to developing countries, this approach has been modified to take into account country-specific situations including data availability, technical capabilities, previous studies, as well as domestic policy goals.

The ICAP work to date has focused on quantifying the air pollution health benefits of integrated greenhouse gas and air pollution control strategies for the energy sector. However, the basic approach could be easily extended in scope to analyze actions taken in the non-energy sectors and additional important co-benefits such as labor and employment-related impacts, water and soil pollution, agricultural and ecological impacts.

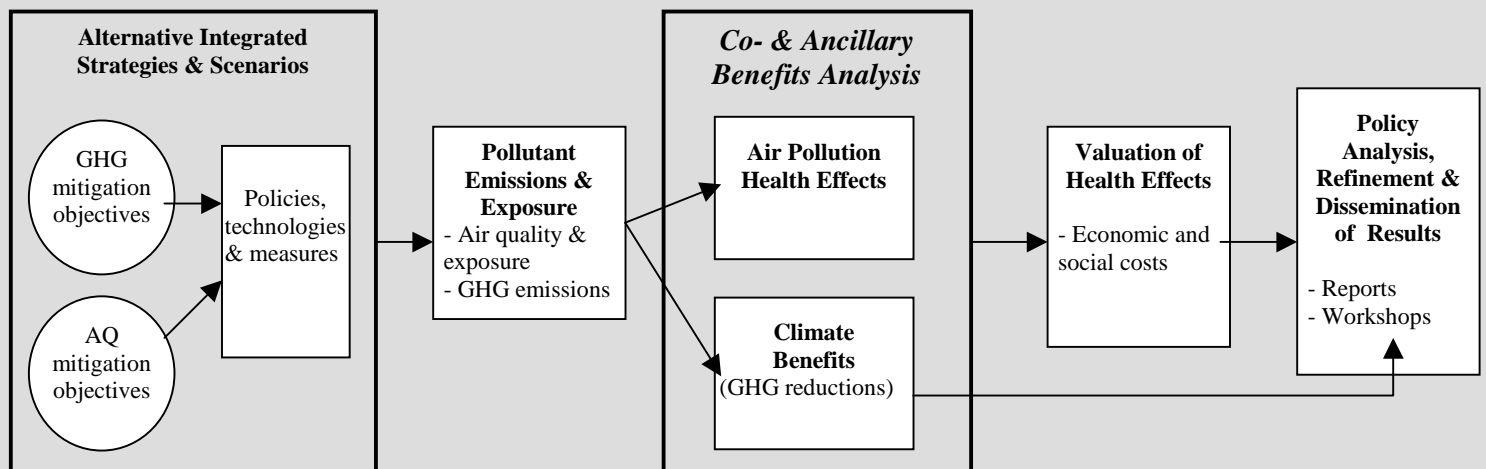
It is important to note that each country is tailoring the ICAP general methodology to meet their unique interests and circumstances. Through the experiences of each country, the U.S. EPA and the National Renewable Energy Laboratory along with Abt Associates, World Resources Institute and other cooperators have been able to test and refine this analytical framework and assessment methodology.

Overview of ICAP Methodology

The ICAP methodology (illustrated in Figure 1.1) includes the following basic activities:

- ❖ Assessment and identification of in-country objectives, data, analytical tools and capabilities leading to the development of an integrated analysis team and study design.
- ❖ Selection and development of air pollution and greenhouse gas mitigation strategies and scenarios.

Figure 1.1 ICAP Methodology



- ❖ Estimation of air pollutant and greenhouse gas emissions and exposure levels of harmful air pollutants.
- ❖ Analysis of the air pollution public health effects (dose/response relationships) of key ambient pollutants and estimation of the potential public health benefits associated with the alternative air pollution and climate change mitigation strategies.
- ❖ Estimation of the economic value of these potential health benefits
- ❖ Analysis of the policy implications of the study results, identification of areas for further refinement and improvement of the analysis and dissemination of results.

Summary of Country Co-Control Benefits Assessment Methodologies

Each country has tailored the overall methodology to reflect their interests and circumstances. Table 1.1 provides an overview of the approach that each country is pursuing with their assessments.

Table 1.1 Summary of Country Integrated Strategy Assessment Methods

Country	Study Region	Climate Policy Scenarios	Air Pollutants Evaluated	Air Pollution Models	Health Effects Evaluated	Economic Valuation Methods	Policy Analysis Methods
Argentina	Buenos Aires Metro Area	Measures under consideration: Energy sectors: Hydro, wind, co-gen, gas flaring, fuel substitution, energy efficiency, and modal shift Waste management: crops, livestock, forestry, solid waste	PM, CO, NO _x , SO ₂	AIRWARE (ISC-3)	Mortality: premature mortality Morbidity: hospital admissions, emergency room visits, restricted activity days, asthma, lower respiratory illness in children, respiratory symptoms and eye irritation	Mortality: VSAL (benefits transfer), WTP, human capital approach Morbidity: Cost of Illness, WTP	Policy Makers Workshop Integrated final project report
Brazil	Sao Paulo Metro Area	Measures under consideration; Transportation sector: new vehicle technology, modal substitution, vehicle maintenance and inspections and introduction of cleaner fuels.	PM ₁₀ , PM _{2.5} , and O ₃	Cal. Tech. CIT model	Mortality: Cardiovascular and respiratory premature mortality Morbidity: a wide range of effects are available for analysis	Human capital: income and foregone income generation; hospital expenditures Benefit transfer functions derived from EU and USA Adjustments of WTP values from hedonic property price from past studies	Policy Makers Workshop Integrated final project report
Chile	Santiago Metro Area	1 Climate Policy Scenario Measures Included: - energy efficiency - fuel switching - Santiago decontamination plan - national strategic plan	PM _{2.5}	Box Model & Source Apportionment	Mortality, asthma, bronchitis, pneumonia, hospital admissions, restricted activity days, etc.	Mortality: human capital approach, WTP benefits transfer, CVM Morbidity: Cost of Illness, WTP	Policy Makers Workshop Integrated final project report Analysis of Ancillary Benefits and \$/ton of C of Specific Measures

Country	Study Region	Climate Policy Scenarios	Air Pollutants Evaluated	Air Pollution Models	Health Effects Evaluated	Economic Valuation Methods	Policy Analysis Methods
China	Beijing and Shanghai	<p>1 climate scenario 2 air quality scenarios</p> <p>Shanghai plan of Action – Agenda 21</p> <p>Measures Include: - Energy efficiency - Coal capacity limit - Electricity imports - Natural gas - Transp. Measures</p>	PM, TSP, SO ₂ , NO _x , PM ₁₀	Point, volume, area, and linear dispersion models linked with Shanghai Environmental GIS (SEGIS).	Respiratory diseases, cardiovascular diseases, cerebrovascular diseases, out-patient and emergency-room visits, clinical symptoms and lung functions	Valuation of health effects will be carried out in subsequent project phases	<p>Policy Makers Workshop</p> <p>Final project report</p>
Korea	Seoul Metro Area	<p>4 Climate policy Scenarios</p> <p>Measures Include: - Energy efficiency - CNG buses</p>	PM ₁₀	UR-BAT	<p>Mortality: Cardiovascular and respiratory</p> <p>Morbidity: Asthma, COPD, respiratory function and symptoms, etc.</p>	<p>Mortality: CVM, VSAL (benefits transfer)</p> <p>Morbidity: Cost of Illness</p>	<p>Policy Makers Workshop</p> <p>Final project report</p> <p>Follow-up project to assess national ancillary benefits of NO_x and SO₂ mitigation</p>

Analytic Design and Development of Integrated Strategies

The participating countries have generally followed three basic steps in the design of their analysis and development of scenarios. These steps include: 1) Convene interagency, multidisciplinary scoping workshops to develop the basic project design, 2) Establish interdisciplinary project teams of in-country experts, and 3) Develop baseline and alternative climate change and air pollution scenarios for the analysis. Each of these steps is described further below:

Convening Scoping Workshops to Define the Project Design.

During these workshops, the countries have convened climate change, air pollution, health effects, economic valuation experts together with policy makers to discuss and develop the project design. Officials from the U.S. EPA, and technical experts from NREL and other institutions have also participated in these workshops. These initial workshops encouraged discussion of the key analytical aspects of each of the main components of the project, the availability of data, and analytic inputs and outputs needed to support each of the linked components. Key project design issues addressed at these workshops have included:

- ❖ **Geographic Scope.** The countries have selected 1 or 2 major metropolitan areas as the primary focus for the development and analysis of integrated environmental strategies. Usually, the metropolitan area, or megacity, selected accounts for a large percentage of the total population and economic activity of the country. In some cases, the countries have decided to attempt to extrapolate health effects and economic benefits results obtained from the megacity analysis to the national level, with appropriate adjustments, in order to estimate the magnitude of national benefits that may be possible through implementation of the integrated environmental strategies.
- ❖ **Sectoral Scope.** The participating countries have focused their analysis on the energy sector and in many cases, used these scoping workshops to identify energy sub-sectors and technologies that could be considered as candidates for the co-benefits analysis. This identification of potential energy sub-sectors and technologies has been based on information from existing studies on the greenhouse gas and air pollution reduction potential of alternative energy technologies and sub-sectors and on the relative contribution of certain sub-sectors to diminishing air quality. The countries generally further refined the selection of energy sub-sectors, technologies and measures through the development of the analytic scenarios as described later in this section.
- ❖ **Preliminary Selection of Pollutants and Health Effects of Concern.** During the scoping workshops, the participants have also identified the key air pollutants and related health effects of most concern for the selected urban areas. Considerations of data availability (emissions inventories, ambient monitoring, concentration response functions, etc.), availability of atmospheric dispersion models and technical capabilities are taken into account in the initial selection of pollutants and the range of health effects that could be considered. In some cases, this preliminary selection of pollutants and health effects were later refined to reflect changes in the energy scenarios evaluated and the availability of data.
- ❖ **Preliminary Selection of Air Pollution Models.** Once the primary pollutants and health effects are identified, the workshop participants then discussed the alternative air pollution dispersion models that could be used for this analysis. Questions concerning the desirability of considering complex chemical and photochemical pollutants were considered within the context of data and technical limitations. The final determination on air pollution dispersion models was often made at later date following further

evaluations of the suitability of the alternative models and data needed to calibrate and run these models.

- ❖ **Design of Economic Valuation.** The workshop participants have determined whether to conduct economic valuation of the health effects and whether this step in the analysis would benefit policymakers with useful and relevant information. Most countries have included economic valuation in their work and have also defined during these workshops the specific economic metrics to be evaluated and the techniques to be used for this economic valuation work. Some countries have chosen to develop new valuation estimates through direct surveys while others have decided to rely on prior domestic studies and international estimates adapted to local economic conditions.
- ❖ **Define Major Products and Schedule.** After determining the basic project design, the participants then outline a schedule of key project milestones and products. Most countries have completed their preliminary analysis of the health benefits of integrated climate change and air pollution strategies within 1 year. Additionally, the project team and interested policymakers have, in all cases, decided that the final dissemination of information in the form of a synthesis report and a policymakers review workshop were essential steps to inform domestic and international policymakers and define further directions for research and analysis.

Establishment of Project Teams

Each country project team is established through consultations and guidance provided by in-country national or state environmental protection agencies. Lead technical coordinating institutions are selected to provide overall technical management for the project and to coordinate involvement of interagency policymaking institutions. These lead technical institutions are usually selected in advance of project initiation and are called upon to organize the initial scoping workshop. Once the basic components of the project design have been determined interdisciplinary project teams are then established in each country. In most cases the other institutions and technical experts are not determined until after the workshop so that experts can be selected that best match the project approach determined at these workshops. EPA and NREL also identify U.S. technical experts to provide technical assistance and guidance to in-country team members for the analysis.

Development of Baseline and Integrated Climate Change and Air Pollution Control Scenarios.

The design of baseline and control scenarios is a critical step in the analysis of integrated environmental strategies. The project teams have put considerable effort into the design of these scenarios. In most cases, countries have designed scenarios to analyze health effects for the years 2000, 2010, and 2020. In many cases, scenarios are developed which reflect assumptions that are drawn from local planning processes such as local Agenda 21 plans, urban decontamination plans, etc. In this way, scenarios reflect policies and measures under consideration for greenhouse gas and local air pollution mitigation and provide direct value to policymakers.

Countries develop 2 basic types of scenarios for this analysis

❖ **Baseline Scenarios.**

These baseline scenarios reflect estimated future changes in energy use at the national level and urban levels consistent with energy development plans. Many countries have chosen to develop a “business as usual” scenario that assumes no change from current energy or emissions control policy. Additionally, countries have also attempted to take into account the effect of anticipated future air pollution controls in separate air pollution control baseline scenarios.

❖ **Integrated Climate Change and Air Pollution Control Scenarios.**

These integrated control scenarios contain estimates of changes in energy use at the national and urban levels based on the implementation of selected energy measures and technologies. Each project team has chosen energy measures and technologies for inclusion in these control scenarios based on the energy measures that are identified as cost-effective for greenhouse gas reduction from existing studies of climate change mitigation options and strategies. Countries are also encouraged to consider information from similar studies of the cost-effectiveness of energy measures for air pollution control so that energy measures can be selected for analysis that will harmonize climate change mitigation and air pollution reduction control. In this initial phase of analysis, however, many countries have decided to focus first on analyzing energy measures that are most cost-effective for greenhouse gas reduction and the ancillary health benefits of these measures. After completing this preliminary analysis countries are revising these scenarios to reflect opportunities to optimize both air pollution and greenhouse gas reduction simultaneously through common measures.

Estimating Pollutant Emissions and Exposure

Most of the participating countries have chosen to focus their initial assessments on health benefits of reducing ambient particulate concentrations. In China, it was also important to investigate health benefits of reducing SO₂ and NO_x. The focus on particulates reflects their significant correlation with health damages from the combustion of fossil fuels and the consequent opportunity for realizing health benefits through implementation of energy efficiency and fuel switching measures that will also decrease carbon emissions. Furthermore, analysis of ambient particulate concentrations is more straightforward than analysis of more complex pollutants such as ozone, which requires a more robust emissions inventory and more complex air quality modeling. Depending on available air quality monitoring data and the level of sophistication of available air quality models, some countries have focused their analysis on TSP, while others have been able to analyze effects of PM₁₀ and even PM_{2.5}.

All of the countries are also evaluating the impact of their climate change policy scenarios on reductions in carbon dioxide emissions. Some countries, Chile for instance, also are evaluating the impact on other greenhouse gases (e.g. methane) and then calculating the carbon equivalent emission reductions after adjusting for differences in radiative forcing of these gases.

The countries are using a variety of air pollution dispersion models for their analysis. Selection of dispersion models for each country was based on the pollutants under consideration, availability of models with prior application to the model domain, and ability of the model to provide credible output results needed for the health effects analysis. Chile has used both a box and source apportionment model and developed estimates using both techniques. Korea is using the UR-BAT model, a modified version of the Lagrangian model used in the RAINS-Asia model and China and Argentina are using models based on the USEPA Industrial Source Complex (ISC) model.

Analysis of Public Health Effects

All of the countries are evaluating the impact of changes in the concentrations of the selected air pollutants on premature mortality and on morbidity. Mortality is estimated as premature deaths from exposure to air pollutants. The measures of morbidity vary from country to country, but generally include the occurrences of asthma, bronchitis, and other respiratory diseases. Some countries (e.g., Chile) are also evaluating the impact of air pollution on the number of restricted activity days.

Exposure-response functions for this study were developed in several ways, depending on the country. In Korea, exposure-response functions for PM10 were developed specifically for this project by applying a Robust Poisson Regression Model to fit the daily count of health outcomes on air pollution levels (PM10). For other countries it was necessary to obtain exposure-response relationships from the literature, first by attempting to use domestic studies from other cities, or adopting international coefficients where appropriate. Some countries developed separate estimates for different age classes (e.g. children, adults, and senior citizens).

Economic Valuation of Public Health Effects

All of the six countries are developing estimates of the economic value of these avoided health effects. The methodology followed requires: a) for mortality, the use of unit economic values as the value of a statistical life, and b) for morbidity: direct costs of illness or medical costs, loss of wages, and the value of individuals' "willingness to pay" to avoid symptoms caused by pollution.

Several alternative methods to calculate the value of a statistical life have been employed, including those related to willingness to pay (WTP) to avoid a given mortality risk and the Human Capital approach. The latter is a lower bound of the former since it uses foregone future incomes as the valuation vehicle, which does not include the subjective value people assign to life. Contingent valuation is being used in some countries to determine the value of premature mortality reductions by determining the willingness to pay of individuals to reduce the occurrence of premature deaths. Korea is currently conducting a CVM study as part of the ICAP effort. However, most of the countries do not have country-specific estimates available of the willingness to pay to avoid premature deaths and therefore are using values from the U.S. EPA that are then adjusted to reflect differences in per capita income and purchasing power between the U.S. and the country.

Cost of illness calculations are being used to estimate the value of the morbidity effects. This cost of illness approach requires calculating the direct and in-direct costs of the health effects, including the cost of treating the illness, insurance costs, value of wages lost during the treatment period, and other related expenses. All six countries are following this approach to estimate the value of morbidity effects. However, as in the case of WTP for premature mortality effects, all unit values for all effects are not available for all countries, hence, some of those unit values need to be approximated from U.S. and/or European estimates adjusted by wage ratios or GDP per capita, or other related correction factors.

Analysis of Policy Implications and Refinement and Dissemination of Results

A critical step in this analysis is the evaluation of the climate change and local air pollution policy implications of the results and refinement of the results to reflect comments and needs of policy-makers. Each of the countries is using workshops with climate change and local air pollution officials and experts as a focal point to evaluate the country assessment results and help

guide further work to address key policy questions. Policy makers (including climate change and air pollution officials) were involved in the initial design of the analysis in each country to help focus the work on key policy issues. In addition, the countries are presenting their interim results to these policy officials at national and local workshops to make these officials aware of the initial results and to guide further work. These workshops are also helpful in identifying opportunities to develop more harmonized climate change and air pollution scenarios for further evaluation since one common goal of many of the countries is to develop integrated energy sector strategies that will be cost-effective for combined greenhouse gas and local air pollution reduction. Several of the countries are also conducting analysis of the ancillary benefits and cost-effectiveness for greenhouse gas reduction of specific energy measures to identify the measures that have the greatest benefits for climate change and air pollution co-control.

Table 1.2 Schedule of ICAP Events and Activities

March – June, 1999	ICAP assessments initiated in Chile, China, and Korea and work to develop methodologies initiated with Argentina, Brazil, and Mexico
November 1999	Workshop held in conjunction with COP-5 where Argentina, Chile, Korea, and Mexico present their methods and preliminary results
March 2000	Parallel meetings at the IPCC workshop on ancillary benefits. Countries present methods, results and opportunities for international collaboration to broaden dissemination ICAP approach
September 2000	ICAP assessment initiated in Argentina
October 2000	Chile, China, Korea complete initial co-benefits analysis and hold in-country workshops to discuss results with policymakers and plan next steps
October 2000	Mini course on co-benefits assessment at the World Bank Clean Air Initiative workshop in Chile
November 2000	COP6 Workshop and summary report to present results to international community
January 2001	ICAP Workplans completed for Brazil and Mexico and analytical work initiated. Exploratory work initiated to develop workplans for ICAP assessments in South Africa and India
March 2001	Latin American regional workshop on ICAP and co-benefits. Countries present, share and discuss methods, results and opportunities for international collaboration.
June-July 2001	Argentina, Brazil, and Mexico complete initial co-benefits analysis and hold in-country workshops to discuss results with policymakers and plan next steps